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# THE (HIGH) RISE OF SMART BUILDINGS

*EQUITY DERIVATIVES*
INSIGHT

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The Banker
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**MOST INNOVATIVE INVESTMENT BANK FOR CLIMATE CHANGE AND SUSTAINABILITY**

# “Any fool can write a book and most of them are doing it, but it takes brains to build a house…”

*Charles Fletcher Lummis, 1859-1928*

# Executive Summary

The global urbanisation picture is clear: by 2050, 68% of the World population will live in urban areas compared to 55% today. By 2030, there will be 43 megacities with more than 10 million inhabitants, most of them developing in emerging regions. The pressure on urban infrastructure is already tremendous and as we reach the limits of horizontal sprawling, vertical expansion becomes inevitable. Indeed, the number of skyscrapers and high-rise buildings is growing exponentially, and their average height continues to increase – sometimes beyond economic logic.

Unfortunately, their rapid proliferation brings new challenges in a world that is becoming increasingly aware of environmental questions. In the USA for example, buildings account for 40% of CO2 emissions when transportation represent 33% and the industry makes up for the remaining 27%. Many studies show that taller buildings are less energy efficient than their smaller counterparts and regulators across the world are starting to blow their whistles.

We now need to build cities in a very different way to ensure sustainability: this is a matter of urgency.

In this note, we explore the recent development of the smart building ecosystem, from the more systematic use of high performance material and implementation of revolutionary elevator technologies to the integration of renewable energy sources and artificial-intelligence-enabled Building Management Systems. The opportunity is massive and many large corporations have decided to refocus their entire strategy on these activities.

Smart buildings will of course be greener – in fact, some of them are already net positive contributors to their local grids. However, as they become more connected and flexible thanks to the thousands of IoT sensors in their walls, they can also improve the quality of life of their occupants: better safety and security, better air quality, better space utilisation…the possibilities are endless.

For the Real-Estate sector, this is a no-brainer: people will demand nothing less than the most advanced environment for their homes and offices. A significant premium will be paid for high-tech properties and employers will be able to attract and retain talent more easily.

As a result, I am in no doubt that the race for the tallest building is about to become the race for the smartest.

Eric Benoist

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# Modern Urbanisation: Sustainability & the City

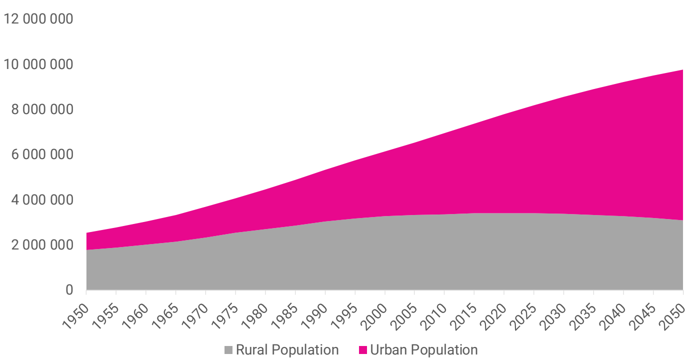
In this section, we look at current global urbanisation trends and their side effects, showing how the race for the tallest building is about to become the race for the smartest.

## PROJECTED GROWTH OF URBAN POPULATIONS

According to the United Nations, in 1950, 30% of the world's population lived in urban areas compared with 55% today. By 2050, that number is expected to rise to 68%. That amounts to an additional 2.5bn people living in cities across the globe, with almost 90% of growth expected to happen in Asia and Africa.

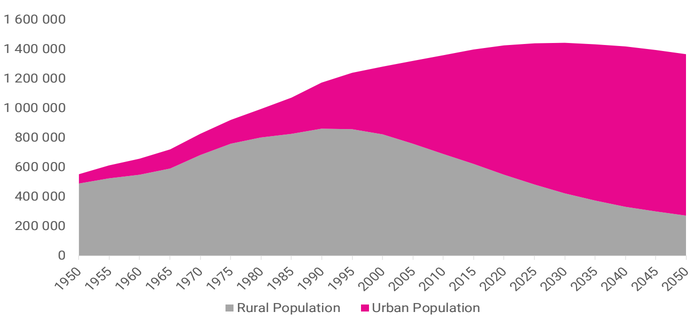
Indeed, if North and Latin Americas now have over 80% of their population in urban areas, Asia only has 50%, and Africa 43%. In the next 30 years, just three countries – India, China, and Nigeria – will account for 35% of the growth in the world's urban population. In absolute terms, this means that India will add 416 million urban dwellers, China 255 million and Nigeria 189 million.

**WORLD - URBAN VS. RURAL POPULATION 1950 - 2050**



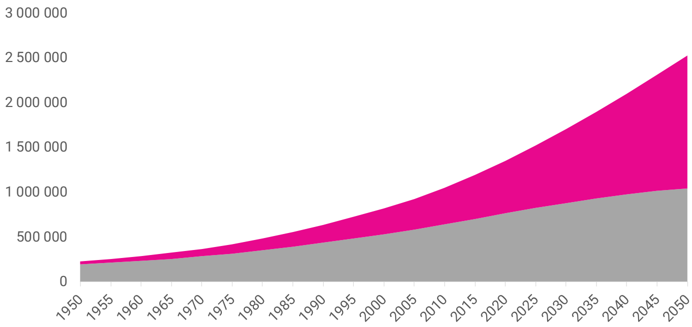

*Source: United Nations, Population Division*

**CHINA - URBAN VS. RURAL POPULATION 1950 - 2050**




*Source: United Nations, Population Division*

**AFRICA - URBAN VS. RURAL POPULATION 1950 - 2050**

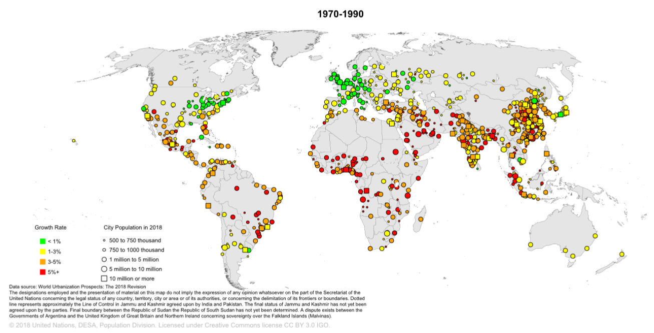



*Source: United Nations, Population Division*

## SPRAWLING OF THE MEGA-CITIES

When a city grows at a manageable rate, which is often considered 1 percent annually, its infrastructure can keep pace with an increasing population and its demands. Necessities such as roads and public transportation, appropriate sewers and water treatment facilities, clinics, schools and housing have time to be planned and built alongside the increase in human numbers.

From the below map however, it is clear that urban growth is expected to be much higher than 1% in many parts of the world.




*Source: United Nations, Population Division*

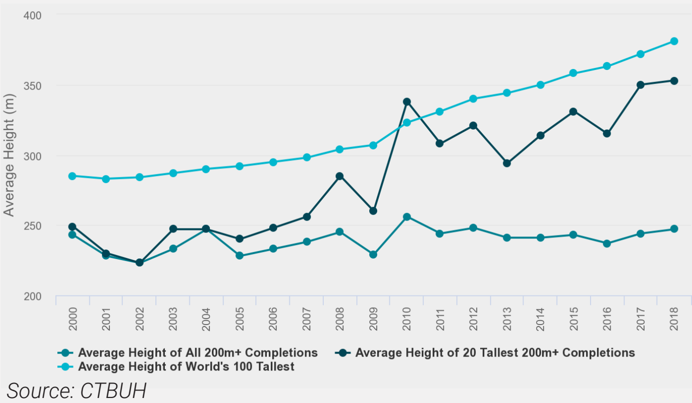
From 33 megacities with more than 10 million inhabitants today, the world is projected to reach a number of 43 by 2030, most of them developing in emerging regions.

Without strategic planning, many of these cities will continue to expand horizontally, often with the emergence of large slums in the suburbs, like in Mumbai, where half of the residents already live in precarious health and safety conditions. A lack of water infrastructure and sanitation combined with high levels of malnutrition may lead to the spread of infectious diseases with potentially devastating consequences for the populations. Meanwhile, poor schooling and education could feed higher unemployment while inefficient law enforcement may favour increased social unrest.

## THE HIGH-RISE SOLUTION

Urbanists around the world have therefore often argued that vertical expansion could present a satisfactory solution to density and infrastructure issues: skyscrapers improve the availability of residential properties without eating too much into large volumes of land or green space. In doing so, they have the potential to reduce housing costs and inequalities. Furthermore, as people gather into smaller geographic areas, urban infrastructures become easier to manage – even if a number of already congested transport systems will continue to be under regular pressure.As the price of land increases everywhere, real estate developers feel compelled to build ever higher. The "economic height" of a skyscraper varies from a country to another: in 1930, W.C. Clark and J.L. Kingston established that 63 storeys were necessary in New York to maximise investment returns. On average, this is not so different from today's numbers. However, buildings are getting increasingly taller, sometimes way beyond the height that economic logic would dictate. Clearly, other "forces" are at stake.

## AVERAGE BUILDING HEIGHT

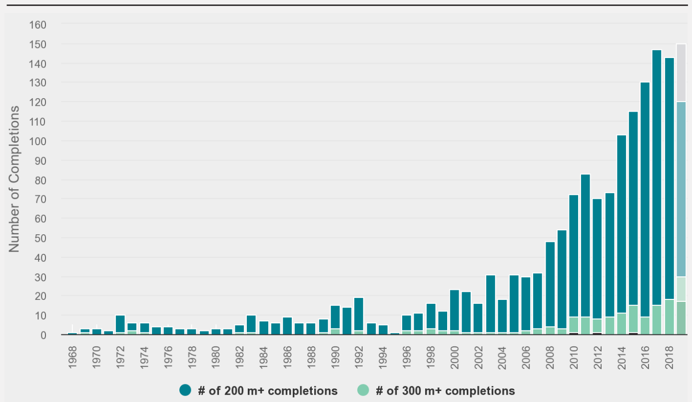



*Source: CTBUH*

Arguably, tall buildings go beyond being a housing and density management tool. In many countries they represent an opportunity to foster growth and build a reputation for business. In 2019, Egypt started erecting a 385m, 80-storey-ultramodern tower, providing panoramic views of the Nile and the pyramids. After completion in 2023, the aptly named "Iconic Tower" will become the tallest structure in Africa: obviously, the Egyptian government is sending a message that after years of instability, the country is now ready for business and is looking to change its image in the eye of new potential economic partners.

Egypt is not alone in this "beauty parade" exercise: tall buildings are multiplying across the planet at an unprecedented pace. According to the Council on Tall Buildings and Urban Habitat (CTBUH), the total number of 200-meter-and-higher buildings in the world is now 1478, a 141% increase from 614 in 2010!

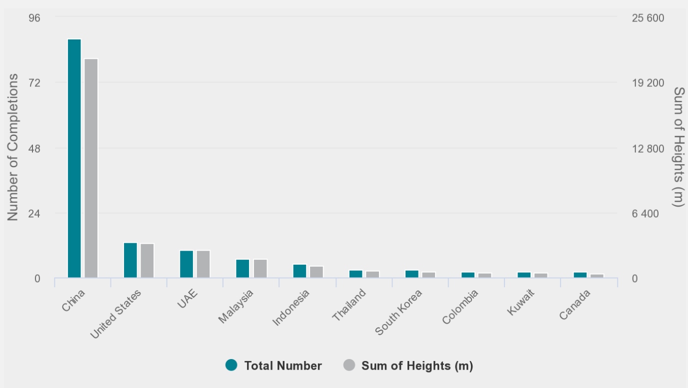
## COMPLETIONS TIMELINE




*Source: CTBUH*

China represents 61.5% of the market, with 88 completions in 2018. The USA come a distant second with 13 completions, followed by the United Arab Emirates (10), Indonesia (5) and Thailand / South Korea (3 each).

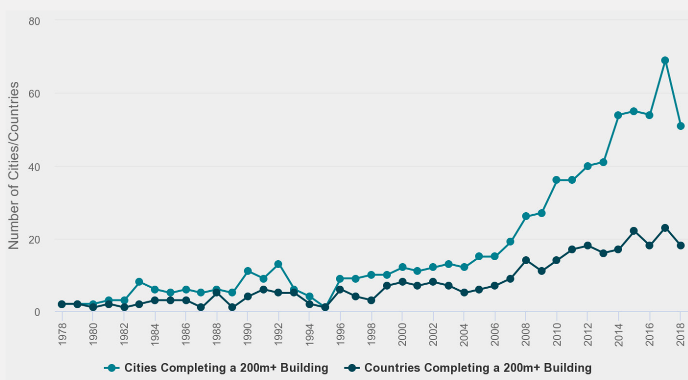
## COMPLETIONS BY COUNTRY




*Source: CTBUH*

Overall, an increasing number of cities and countries have now recorded the completion of a 200-meter-plus building:

## GEOGRAPHIC DIVERSITY




*Source: CTBUH*

Going forward, emerging economies are likely to attract the bulk of new super high-rise projects, as construction costs and labour are much more affordable than in developed countries. Jason Barr, professor of urban economics at Rutgers University in Newark estimates that an unskilled construction worker in New York is paid $17.57 per hour, while the same type of workers in China receive about $3.36 dollar per hour. In India, wages are closer to $0.63 dollars per hour. When labour costs represent up to 50% of the total cost of the building in the USA, it makes sense for developers to focus on other parts of the world instead.

## CONSTRUCTION COSTS FOR SOME SKYSCRAPERS AROUND THE WORLD

| Building | City | Floors | Height (meters) | Year | Cost (bn USD) | Cost per Floor (M USD) |
|---|---|---|---|---|---|---|
| **One World Trade Center** | New York City | 104 | 541 | 2014 | 3.9 | 37.5 |
| **Shanghai Tower** | Shanghai | 121 | 632 | 2015 | 2.4 | 19.8 |
| **The Shard** | London | 73 | 306 | 2013 | 1.9 | 26 |
| **Taipei 101** | Taipei | 101 | 509 | 2004 | 1.8 | 17.4 |
| **Burj Khalifa** | Dubai | 163 | 828 | 2010 | 1.5 | 9.2 |

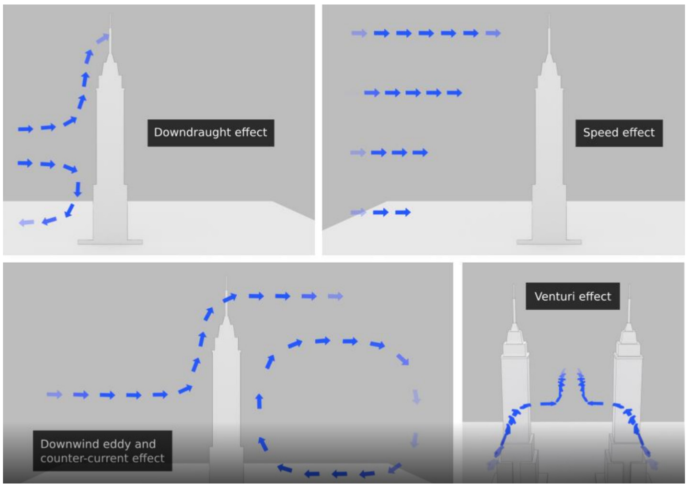
*Source: Emporis*

## FLIP SIDE OF THE COIN

Vertical expansion is indicative of the future shape of our cities and, as high-rise buildings continue to proliferate in all shapes and sizes, new problems are beginning to emerge:

- Thoughtless building design or placement has led to a deterioration of climate conditions in some urban areas: Peter Bosselman, professor of urban design at the University of California, argues in "Sun, Wind and Comfort" that tall freestanding towers can generate "tremendous drafts down their side" and increase unwanted wind force at street levels with unpleasant consequences for the populations.

**BASIC URBAN WIND EFFECTS**




*Source: Rheologic.net*

- Entire city sections are plunged in the shadows of tall buildings and although many mayors require Sunlight Access and Shadow Impact studies before granting planning authorisations, many experiments point to the dreadful consequences for mental health and wellbeing of excessive high-rise developments. Professor Colin Ellard, a cognitive neuroscientist at the University of Waterloo in Canada, found that being surrounded by tall buildings produces a "substantial negative impact on mood". He argues that "when people are in these very dense environments that produce oppressiveness and increase negative emotion, it seems logical that those things will spin off into the ways we understand other people and the way we treat them" and that "those are the variables that are most likely to show relationships with [increased incidence of] psychiatric illness." Indeed, according to the Centre for Urban Design and Mental Health, city dwellers have a 40% increased risk of depression and double the rate of schizophrenia.

- Perhaps, even more importantly, the environmental impact of high-rise buildings is becoming increasingly negative. In New York for examples, buildings represent 95% of the total electricity use and 70% of the total carbon emissions of the city. In London, researchers at UCL's Energy Institute have found that electricity use, per square metre of floor area, is nearly two and a half times greater in high-rise office buildings of 20 or more storeys than in low-rise buildings of six storeys or less. Gas usage also increases with height, by around 40%. As a result, total carbon emissions from gas and electricity from high-rise buildings are twice as high as in low-rise. Unsurprisingly, on average, carbon emissions from air-conditioned offices are also 60% higher than those from offices with natural or mechanical ventilation. According to the same source, these discrepancies could potentially be explained by the physical and meteorological consequences of building higher: air temperature decreases with height, and average wind speed increases; taller buildings are more exposed to those strong winds as well as to more hours of direct sun, thus affecting energy use.

## RISE OF THE SMART BUILDINGS

Given the projected growth of global urban populations over the next 30 years, the question of the sustainability of current urbanisation trends is becoming crucial. As a result, building the tallest towers soon will not matter as much as building the smartest ones.

As the General Public becomes increasingly aware of carbon footprint impacts, regulators in major cities are likely to impose much more stringent emission targets forcing Real Estate developers to comply in order to avoid hefty fines. In New York City, perhaps the most iconic high-rise city on the planet, Mayor De Blasio passed one of the most aggressive climate bills ever designed as an effort to abide by the Paris climate-change agreement even after the Trump administration withdrew the US from the global accords. The city's first big milestone arrives in 2030: by then, New York buildings will need to have collectively cut their carbon emissions by 40%. Any building larger than 25,000 square feet will be subject to the cap, which means around 50,000 buildings in total. The plan is still work in progress but heavy investments - in the billions of USD - will need to be made sooner rather than later in order to reach the designated short-term targets.

# How Smart Can a Building Be?

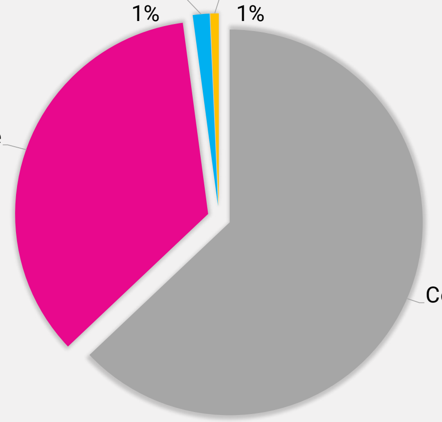
In this section, we look deeper into the concept of smart buildings and the solutions that they bring to the challenges of today's global urbanisation trends.

## SMART BY DESIGN

Architects are under increasing pressure to find alternative ways to build for the future. Designing smart buildings certainly starts with a more systematic use of high performance material and implementation of leaner construction processes.

Concrete remains the most prominent primary structural material for high-rise buildings. It is very resistant to fire as well as water, and due to its inherent heftiness, mass and strength, it can withstand winds of more than 200 miles per hour. Insurers tend to look favourably on reinforced concrete structures, as they appear safer and reduce liability on their part in case of a disaster. However, concrete is extremely labour intensive, requires regular maintenance and repair throughout its lifetime cannot be recycled and has a very negative carbon footprint. Around 4bn tons of cement are produced every year: if the cement industry was a country, it would be the third largest emitter in the world behind China and the USA. It is the source of 8% of the world's CO2 emissions according to think tank Chaltham House (just behind the global agriculture business, 12%, but far ahead of the aviation industry, 2.5%). Although it would be naïve to expect a complete reversal in concrete and cement consumption trends, we anticipate a progressive shift into other types of materials.

**200-METER-PLUS BUILDINGS COMPLETION IN 2018 BY TYPE OF MATERIAL**




*Source: CTBUH*

Steel, for example, has a bright future in our opinion. It is already used to produce reinforced or ultra-high performance concrete for skyscrapers' cores, but we feel it will also increase its market share as a standalone material. It has a very high strength to weight ratio, is very ductile and allows for lighter structures and lower loads on foundations while maximising habitable space thanks to smaller elements (the footprint of a column is approximately 10 times smaller in steel than in concrete). It can be used to create bolder shapes and finely sculpted curves, better fitting the general city landscape and architectural heritage in which it is introduced. It is a lot less labour intensive: parts can be fabricated in workshops and assembled onsite by a smaller workforce. New techniques such as modular steel construction allow for super-slender buildings to be erected in very short period of time on very small parcels of land: in 2015, Chinese firm BSB managed to erect a 57-storey tower in Changsha in less than 20 days. Similarly, in Melbourne, the 60-storey Collins House will be Australia's slimmest skyscraper upon completion this year with an almost shocking 12.5m width! Here, faster returns on investment are not standing in the way of a cleaner and more sustainable construction industry: pre-fabricated steel modules generate less on-site waste, less disruption to the surroundings (noise) and are safer to manipulate. Steel is 100% recyclable without quality loss and Arcelor-Mittal estimates that the high strength material used for buildings such as One World Trade Centre in New York or the Emirate Tower One in Dubai can reduce CO2 emissions during construction phase by as much as 30%. High performance steel will help reduce the industry's heavy carbon footprint (4% to 7% of global emmissions) and will continue to gain market share for that reason. Finally, fire safety concerns can be mitigated by chemical coating and spray-on fireproofing treatments.

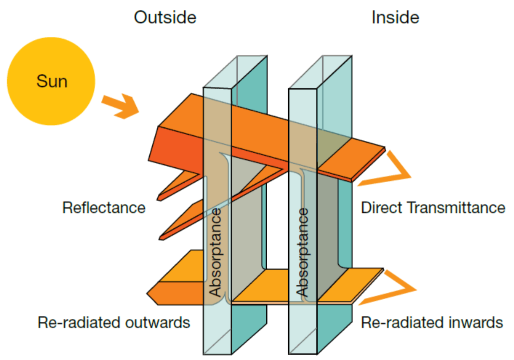
With recent technological breakthrough, wood may also become more prominent in high-rise projects. For example, laminated veneer lumber has a strength to weight ratio that is 20% greater than steel and cross-laminated timbers have the same strength as concrete. They are also a lot lighter and easier to transport. Despite a huge perception problem, their resistance to fire is excellent (they will char but won't break or melt). In a world that uses a lot less paper, they can be supplied in a more sustainable way. Finally, it provides a naturally relaxing environment, with many scientific studies showing a positive impact on people's physical and mental health. Unfortunately, it is not cheap and probably won't become mainstream until costs are under control. Japanese timber company Sumitomo Forestry intends to show us the way with their new head office W350 project. They are simply planning the world's tallest wooden building in Tokyo for 2041 - a 350m skyscraper wrapped in large balconies covered in plants - at an astronomical cost of 5.5bn USD.

**THE SUMITOMO FORESTRY W350 PROJECT**

*Source: www.dezeen.com*

De Blasio sensationally said last year that glass was not welcome anymore on his NYC skyline. Indeed, in its basic form, it does let a lot of light in during the summer months and a lot of heat out in the winter, forcing a suboptimal use of air-conditioning and ventilation systems on an almost permanent basis. And yet, glass-fronted buildings remain highly popular amongst corporate clients: everyone wants a building to match their reputation, and the look, and feel, of those modern "cathedrals" of light is hard to beat. We think this is unlikely to change anytime soon. Many scientific studies prove that workers in daylit environments suffer less physical stress. A Cornell University report found that in those facilities with natural light pouring in, there is a 51 percent drop in symptoms of eyestrain and 63 percent decrease in headaches, both of which can detract from productivity. Alan Hedge, professor in the Department of Design and Environmental Analysis at Cornell, argues that, "as companies increasingly look to empower their employees to work better and be healthier, it is clear that placing them in office spaces with optimal natural light should be one of their first considerations". Unfortunately, although glass is made of abundant non-polluting raw material, requires low level of water and generates little waste, it is not without its own challenges. In the UK for instance, Building Regulations will not authorise a fully glazed façade if it leads to the heavy use of mechanical ventilation systems to avoid overheating. There are smart solutions however. The industry has developed technological products such as double and triple glazed solar control low-e glass to allow sunlight to pass through a window while radiating and reflecting away a large degree of the suns' heat. The Shard Building in London has a dynamic double skin façade: the outer glass is separated from the inner double-glazing by an intermediate ventilated cavity. Automated blinds react to the sun's path to maximize daylight and views while minimizing solar radiation for the building's occupants.

### GLASS & SOLAR HEAT RADIATION



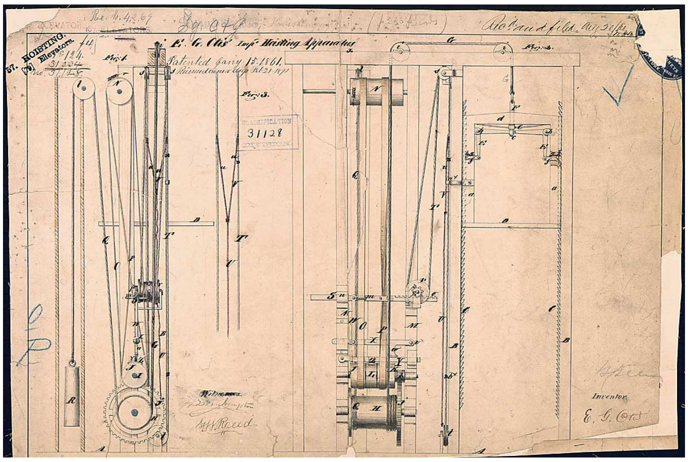

*Source: Pilkington Group*

According to trade association Glass for Europe, 94.3Mt $CO_2$ could be saved annually by 2030 if all windows in Europe were changed with readily available high-performance glazing. This corresponds to a 30% reduction in the energy consumption of buildings. Nearly half of the maximum saving potential identified for 2030 could be realised in 10 years by doubling the current annual window renovation rate of 2%. In smaller buildings, the use of more expensive electrochromic or "switchable" glass technologies (activated by a low-voltage electric current to adapt their light and heat transmission to the level of sunlight or the building's ambient temperature) could improve energy savings further.

## SMART ELEVATORS

In 1853, Elisha Otis introduced a basic device that could prevent an elevator from crashing after its cable rope broke. For many historians and architects, this marked the beginning of vertical urbanisation, as we know it. Indeed, a few decades on, industry experts estimate that 12-15 million elevators are making 7bn trips per day for 1bn passengers worldwide. 165 years of continuous development have brought a tremendous streak of improvements to our cabins: from an original speed of 0.2m/s in low-rise factory buildings, elevators are now traveling distances of 500 meters or more at average speeds of 10m/s, sometimes even peaking at 18m/s like in the case of the Shanghai Tower. In supertall buildings, they typically descend faster than commercial airplanes and need to be fitted with aerodynamic upgrades to minimise the impact of air displacement on the general infrastructure. They also need to be pressurised to avoid ear-popping discomfort at the passenger level…Thankfully, safety systems have not been forgotten in the process: the number of elevators' fatalities has remained very small. In fact, freefall accidents have occurred only twice in recent years: in 2001, as a result of the 9/11 terrorist attacks on the WTC and in 1945, when a B-25 bomber crashed in the Empire State Building in adverse weather conditions.

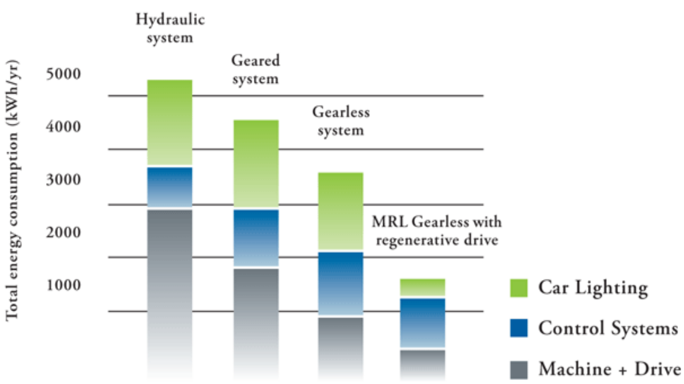
### ELISHA OTIS'S ELEVATOR PATENT DRAWING, 1861



*National Archives, USA.*

Elevators represent 10% of a building's average energy consumption. During peak hours, they can use up to 40% of the total. Hence, improving their energy efficiency has long been the focus of the industry: smaller gearless motors, machine-room-less technologies and regenerative drives capturing braking energy, have already helped reducing consumption by 20 to 40% depending on the size of the building where they have been implemented.

### ELEVATORS: ENERGY CONSUMPTION BY SYSTEM TYPE

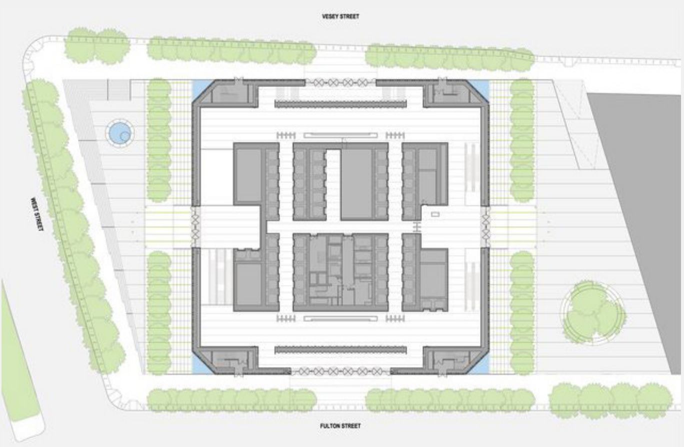



*Source: OTIS*

Recent progress on cable rope material has also created new opportunities. A 2015 study by the University of Illinois explains that in very tall buildings, almost 70% of the elevator's weight is attributed to the cable itself and that when the rope is too long, it cannot support its own weight. Kone's "UltraRope" changes this: it is comprised of a carbon fibre core and a unique high-friction coating, making it extremely light, and allowing cars to travel up to 1000m. The reduction in weight minimises the energy needed in the acceleration and deceleration phases, saving another 15% on consumption.

In most high-rise buildings, elevator shafts are taking too much space, sometimes up to 40% of a building's floor. Clearly, finding ways to reduce their numbers and size has become essential to making buildings more profitable and more efficient. In that respect, exciting industry developments are about to receive approval from various regulators around the world. For instance, ThyssenKrupp's MULTI elevator concept is truly ground-breaking: motors attached at the back of each cabin are powered by electromagnetic coils embedded in the rear wall of the shaft. Smaller, lighter, rope free cars can move vertically and horizontally in buildings of all heights. 10 or more cabins can be operated in one single shaft. Computer algorithms direct them along optimal routes and ensure they never collide. With this set-up, ThyssenKrupp estimates that the amount of real estate lost to elevator infrastructure can be reduced by as much as 25% per building. We expect this product to revolutionise high-rise design as architects are no longer constrained by the number of vertical concrete shafts positioned along the core of the buildings. They also don't need to build higher in order to breakeven as more space becomes naturally available.

**ONE WORLD TRADE CENTER, GROUND FLOOR PLANS**




*Source: Skidmore Owings & Merrill LLP*

**THE MULTI ELEVATOR SYSTEM**

*Source: https://multi.thyssenkrupp-elevator.com*

## SMART SOURCES OF ENERGY

True "Net Zero-Energy" buildings are very rare. The US Department of Energy estimates that on average, office buildings consume 17.4 kWh of electricity per square foot per year – although that number may greatly vary depending on the type of activity taking place inside the walls (trading floors or restaurants do cost more than traditional commercial operations). A skyscraper like the Shard offers 126,000 square meters of floor area and might therefore need 24M kWh of electricity per year. As discussed earlier, these impressive numbers can be reduced through high performance material or smart elevator systems. However, in order to generate the remainder of the necessary power, it is generally necessary to stay on-grid as integrated renewable energy solutions are often insufficient. Nevertheless, it is possible to better harness natural resources at our disposal to get closer to self-sufficiency. Smart Buildings typically rely on several technologies at the same time. Wind and solar are the most widespread.

Wind turbines, although popular with architects, can be hard to monetise. Wind power is directly proportional to the swept area of the blades and to the cube of the wind speed. Most rooftop areas are too small to have large rotors attached to them and in many city centres, wind speed is too irregular to generate a stable flow of energy. Turbines need a laminar air flow to be fully effective and rooftop currents are often too turbulent for a smooth functioning. Moreover, large turbines can generate significant noise and vibrations, may compromise the entire structure of a building and won't be easily retrofitted for that reason. It may also become necessary to switch them off at night for the occupants' comfort, like at the Strata Tower in London where the 1.5M GBP turbines were initially designed to cover 8% of the building's energy needs, but are now thought to be producing closer to zero. However, in better engineered projects like the 309m Pearl River Tower in Guangzhou, the exterior body of the building has been shaped to direct wind to four large turbines into the belly of the tower, adding 1 million kWh of electric capacity each year or 2% of its energy needs.

**ONE OF THE WIND TURBINES AT THE PEARL RIVER TOWER IN GUANGZHOU, CHINA**

*Source: www.placetech.net*

Solar energy is more adapted to low-rise isolated developments like the Apple Park building in California or the Tesla Gigafactory in Nevada. High-rise rooftops are generally too small to accommodate any significant sun-farming capabilities and space is often not available at ground level to install photovoltaic panels in the close vicinity. Using the walls instead is the obvious solution but yields lower efficiency as the sun's radiations cannot hit the panels at an optimal angle. In denser urban agglomerations, the cells might even spend a large part of the day in the shadow of other buildings and remain largely inactive. Solar products, like the standard crystalline silicon semiconductors that dominate the industry, sacrifice transparency to maximise efficiency and are hardly satisfying as window material (they are either opaque or semi-transparent and absorb ultraviolet or infrared wavelength giving the building an unappealing exterior appearance). Transparent photovoltaic glass is available, but the technology is new and costs twice as much as a standard glass. For now, we are unlikely to see fully transparent solar façades on skyscrapers but smaller, more affordable projects can still have a very positive impact on the infrastructure: for example, the 2640m2 photovoltaic pergola located at the entrance of the 290m Tanjong Pagar tower, in the heart of the Singapore financial district, generates 125.8 kWh per year and enables the building to supply over 7000 lights per day. Similarly, the photovoltaic cells integrated into the external shading system located on the east and west elevations of the Pearl River tower contribute 2% towards the building's annual energy needs.

Other more exotic routes have emerged. They may be more bespoke, fit smaller buildings and be limited to powering up specific parts of a larger installation. Treadmills and exercise bikes at the local gym can be equipped with micro-inverters to send energy from your workout back to the grid. This might make you feel like a hamster in a wheel but ride a bike for an hour and you might generate enough electricity to keep a 25W light bulb switched on for a day! Piezoelectric components placed along busy corridors or in large public lobbies will also generate power as people step on them. For example, the walkways of the Westfield shopping centre in Stratford near London have been equipped with tiles that contribute to powering 50% of the building's exterior LED lighting…The production of biogas through the decomposition of organic matter (food waste, plants, sewage…) by anaerobic bacteria in custom bioreactors (or digesters) is another interesting way to generate heat and electricity…Finally, at the Edge building in Amsterdam, a 130m deep Aquifer thermal energy storage system generates all the energy required for heating and cooling the premises.

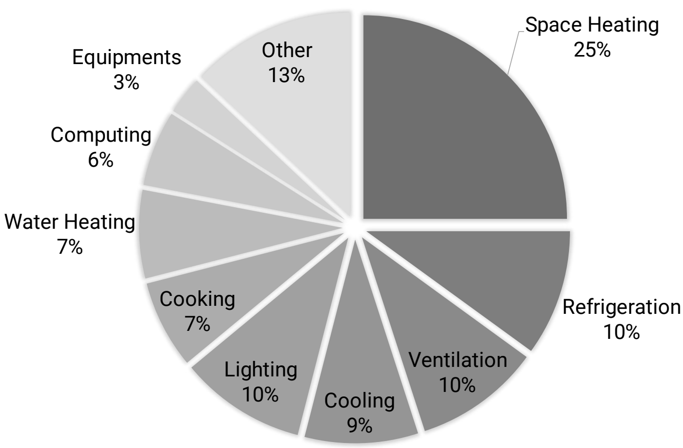
As our scientific knowledge progresses, "energy positive" buildings, i.e. net positive contributors to the local grids, may become a more frequent sight. In the meantime, we are still likely to see renewable energy technologies become part of any new real estate project as a way to reduce carbon footprint and improve environmental impact. The retrofitting industry will also benefit from more stringent regulation worldwide as existing buildings are progressively forced to adopt a much greener agenda.

## SMART AI AND IoT

Whilst renewable energy sources will increasingly contribute to a more sustainable coverage of our energy needs, it is perhaps even more crucial to find ways to reduce our consumption in the first place. In that respect, artificial intelligence and smart Building Automation Systems are about to revolutionise the way that our buildings operate and perform.

When traditional HVAC (Heating, Ventilation, Air-Conditioning) systems run 24/7 and account for more than 50% of a commercial building's total energy consumption, AI-enabled HVACs can sense human presence and switch on specific units based on actual building occupancy, leading to typical cost savings of 20% to 30% per year. By constantly assessing internal and external conditions and taking into account each user's preferences, temperature is autonomously controlled and optimised. Air quality is also tighly monitored and ventilation, filtration, purification systems are triggered when Particular-Matter-Smaller-than-2.5-micrometres (like dust or pollens), Volatile Organic Compounds (like carbon monoxide, ammonia etc.), or excessive humidity are detected.

**ENERGY CONSUMPTION IN US COMMERCIAL BUILDINGS - 2012**




*Source: US Energy Information Administration, www.eia.gov*

Ultimately, AI-enabled HVAC systems also use predictive modeling to foresee when a breakdown may occur giving contractors the time to intervene and lowering the risk of a complete shutdown. When a problem eventually happens, they can quickly point technicians in the right direction and suggest an efficient course of action. This generally results in lower maintenance costs, fewer HVAC repairs and lower insurance premium due to the removal of castastrophic equipment failure risks.

Water Management can also be optimised and consumption monitored by sensors positioned throughout the water grid, enabling immediate detection of leaks and allowing precision irrigation of plants and green areas.

Intelligent Lighting is another obvious application. It is well known that simple LEDs reduce energy consumption and emit far superior light compared to fluorescent technologies. However, the real transformation in lighting technology isn't limited to the illumination source. Devices are now able to communicate with each other automatically sharing information about occupancy and light level from neighbouring luminaires. Intensity can rise or drop seamlessly with people as they move through the space. If the sourrounding configuration changes, the system adjusts automatically. When lighting still represents roughly 10% of a building's total energy consumption, this is a great way to reduce costs further. Finally, the adaptation of light to human biorythm is becoming an increasingly important topic: indeed, active light regulation ensures that employees stay active and motivated throughout the workday.

Artificial Intelligence also allows a more efficient "people flow" management. Through various techniques involving facial recognition, RFID sensing or motion detection, smart buildings will be able to follow your moves more accurately and do things like allocating parking spots as you arrive in the morning, or sending elevators your way as you leave your desk in the evening, easing pressure on the infrastructure and limiting congestion in public areas. In a world that's wasting 1.3 billion tonnes of food every year (www.fao.org), corporate restaurants will be able to manage the number of meals that they need to prepare as kitchens are informed in real time of how many employees are in the building.

Lifestyles are changing: millenial demographics require a more flexible workspace where people can interact smoothly with their immediate environment and stay connected with the rest of the world at all times. The Internet of Things opens up many possibilities from superfast wireless video-conferencing to smart meeting room management and personalised traffic updates for a more comfortable commute.

Last but not least, AI will provide better safety and security for the occupants. In emergency situations, the building will be able to detect the presence of individuals on any floor and inform first responders of their exact location for a faster and more efficient rescue operation. Access to smart buildings will be regulated by video surveillance software capable of monitoring and analysing the data from hundreds of cameras on multiple sites. Floor access will be automatically restricted to authorised personnel and intruders will quickly be spotted by security teams. The cyber aspect of security will also become more important: as everything becomes more connected, anything can potentially be hacked into and requires more sophisticated levels of protection.

Eventually, the smartest buildings will attract the greatest valuations irrespective of their height. Not only will regulators drive the push for greater energy efficiency, but business owners and employees will also demand the level of comfort and security that only they can provide. As our cities continue to expand vertically, we believe that this new “high-rise economy” is promised a very bright future.

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